$$MaxNoV\_perDevice * AA / [1 - Reserved\_Factor - MaxAggRate\_perDevice / TR] \leq T$$

$$\leq (1 - Reserved\_Factor) * B_{max} / \{Buffer\_Multiplcity * [(1 - B\_Save) * (\Sigma_{i=1}^{Nov} P_i)]\} \qquad (15)$$

In the practice of the disclosed methods and systems, Resource Model Equations (13), (14) and (15) may be employed for I/O admission control and read-ahead estimation in a manner similar to that previously described for Resource Model Equations (9), (10) and (11).

It will be understood with benefit of this disclosure that the previously described example of a double buffering scheme represents just one embodiment of a double buffering scheme that may be implemented to reduce buffer consumption. It will also be understood that such a double buffering embodiment is exemplary only, and that other types of multiple buffering schemes may be employed including, but not limited to, triple buffering schemes that may be implemented to address hiccups in continuous information delivery environments.

Resource Modeling for Integrated Logical Memory Management Structure Implementations

In those embodiments employing the previously described integrated logical memory management structure (*e.g.*, logically partitioned buffer memory, cache memory and free pool memory), the presence of cache in the storage processor means that the total available memory will be shared by cached contents and read-ahead buffers. For example, in one exemplary embodiment the total available memory for a storage processor may be represented by the parameter "RAM", the parameter "M_Cache" may be used to represent the maximal portion of RAM that a cache/buffer manager is allowed to use for cached contents, and the parameter "Min_Free_Pool" may be used to represent the minimal free pool memory maintained by the cache/buffer manager. The parameters RAM, M_Cache, and Min_Free_Pool may be obtained, for example, from the cache/buffer manager. In this exemplary embodiment, the total available memory for the read-ahead B_{max} may be expressed as:

$$B_{max} = RAM - M\_Cache - Min\_Free\_Pool \tag{16}$$

When such an integrated buffer/cache memory embodiment is implemented there are at least two different ways in which a viewer may consume available resources (*e.g.*, I/O, memory, *etc*). In one case, a given viewer may be reading information for its read-ahead buffer from one or more storage devices and therefore consume both buffer space and I/O capacity. In another case, a given viewer may be able to read information from the cache portion of memory, and thus only consume buffer memory space. As described in United States Patent Application Serial No. 09/797,201 which has been incorporated by reference herein, one embodiment of integral buffer/cache design may be implemented to reserve a read-ahead size of contents from the cache manager or storage processor for the viewer in order to avoid hiccups if the interval is replaced afterward. Further, such an integrated buffer/cache design may be implemented to discount the read-ahead size of cached contents from cache memory consumption and make it accountable as a part of buffer space consumption.

When such an integrated buffer/cache memory design is employed, the disclosed methods and systems may be implemented in a manner that differentiates the above-described two viewer read scenarios, for example, by monitoring and considering the number of viewers reading information from storage devices (*e.g.*, disk drives) and/or the number of viewers reading information from cache portion of memory. For example, in one exemplary embodiment the total number of viewers that are currently reading their contents from storage devices ("NoV_IO") may be tracked or otherwise monitored. Only these NoV_IO viewers require I/O resources, however all NoV viewers need buffer spaces. In this exemplary embodiment, NoV_IO may be considered in the disclosed resource model by modifying respective Resource Model Equations (13), (14) and (15) as follows:

For single storage device case:

$$NoV\_IO * AA / [1 - Reserved\_Factor - (\Sigma_{i=1}^{NoV\_IO} P_i) / TR] \leq T$$

$$\leq (1\text{- } Reserved\_Factor)^{*}B_{max} / \{Buffer\_Multiplcity^{*}[(1 - B\_Save)^{*}(\Sigma_{i=1}^{Nov} P_i)]\} \qquad (17)$$

For multiple storage device case under substantially balanced conditions:

$$(Skew/NoD) *NoV\_IO *AA / [1\text{- } Reserved\_Factor - (Skew/NoD) * (\Sigma_{i=1}^{NoV\_IO} P_i)/ TR]$$
$$\leq T \leq (1\text{- } Reserved\_Factor)^{*}B_{max} / \{Buffer\_Multiplcity^{*}[(1 - B\_Save)^{*} (\Sigma_{i=1}^{Nov} P_i)]\} \qquad (18)$$

For multiple storage device case under substantially unbalanced conditions:

$$MaxNoV\_perDevice * AA / [1 - Reserved\_Factor - MaxAggRate\_perDevice / TR] \leq T$$
$$\leq (1\text{- } Reserved\_Factor)^{*}B_{max} / \{Buffer\_Multiplcity^{*}[(1 - B\_Save)^{*}(\Sigma_{i=1}^{Nov} P_i)] \} \qquad (19)$$

In the above Resource Model Equations (17), (18) and (19), the total available memory for read-ahead B_{max} may be calculated using equation (16). The lower bounds may be calculated using the total number of viewers that are currently reading from disk drives NoV_IO. The upper bounds may be calculated using the total number of viewers supported by the system (NoV). Resource Model Equations (17), (18) and (19) may be employed for I/O admission control and read-ahead estimation in a manner similar to that previously described for Resource Model Equations (13), (14) and (15).

When an integrated buffer/cache memory embodiment is employed, an optional buffer read-ahead buffer cap or limit may be implemented to save memory for cache, for example, in situations where workload is concentrated in only a portion of the total number of storage devices (*e.g.,* workload concentrated in one disk drive). Such a cap or limit may become more desirable as value of aggregate consumption or playback rate P_i gets closer to value of storage device transfer rate capacity TR. With onset of either or both of these conditions, increases in read-ahead buffer size consume memory but may have a reduced or substantially no effect